SOLAR PHYSICS :PHYSIQUE SOLAIRE: SCIENTIFIC OBJECTIVES UPDATE

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- Effect of the active regions on the inflection point position
- Solar oblateness
- Differential rotation
- Center to limb variation
- Long term solar diameter evolution
- Modeling using the Ca II images
- Solar radiometry and spectrometry
- Venus transit
- Solar modeling
- Strategy

Conclusions

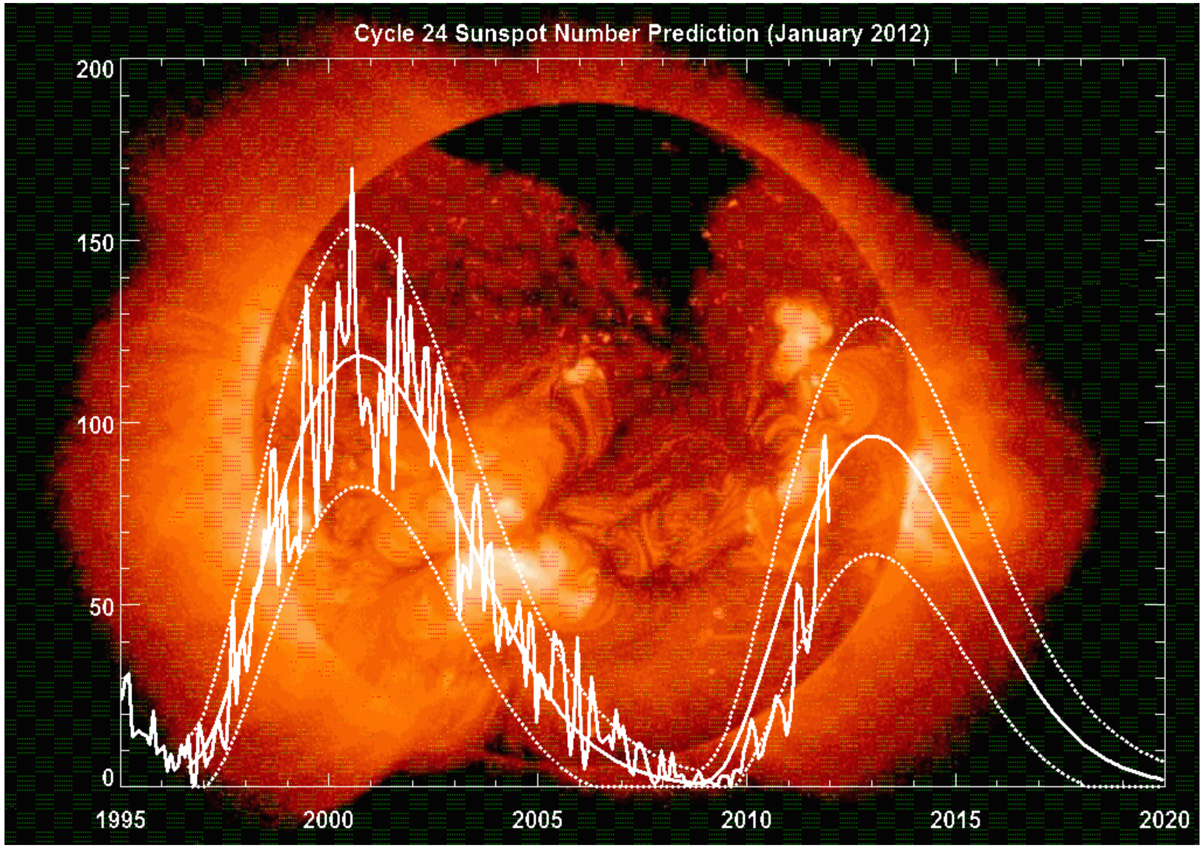
INSTRUMENTS MEASUREMENTS and MISSION

SODISM: solar diameter, CLV, helioseismology, active regions

PREMOS: TSI and several spectral channels

SOVAP: TSI

BOS: Incoming flux from Sun, lower atmosphere and Earth surface



ACTIVE REGIONS INFLUENCE ON THE INFLECTION POINT POSITION

Several studies are based on the inflection point position such as diameter and oblateness determination, helioseismology measurements.

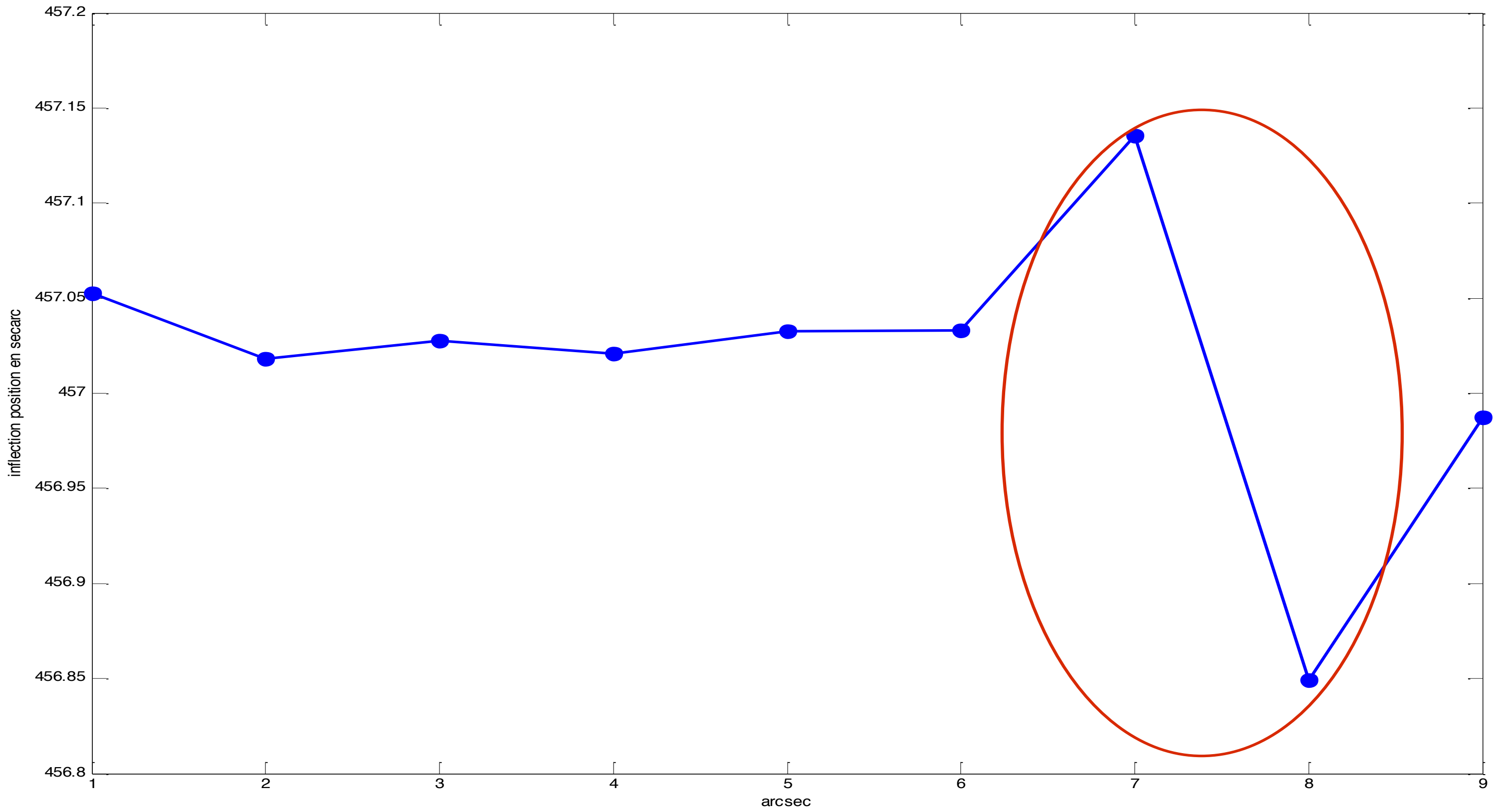
The presence of the active regions at the limb may alter the determination of the inflection point position detected by optical measurements.

Sunspots effects are known as the Willson effect.

Sunspots displace inward the IP, while the facula have the opposite effect.

How solar photosphere models predict this effect?

At a given location of the limb, the inflection point position is calculated. A sunspot is approaching (position 1, 2, 3 pixels ….) and up to the limb. The Willson effect reache 200 mas. It exists cases with greater effect.



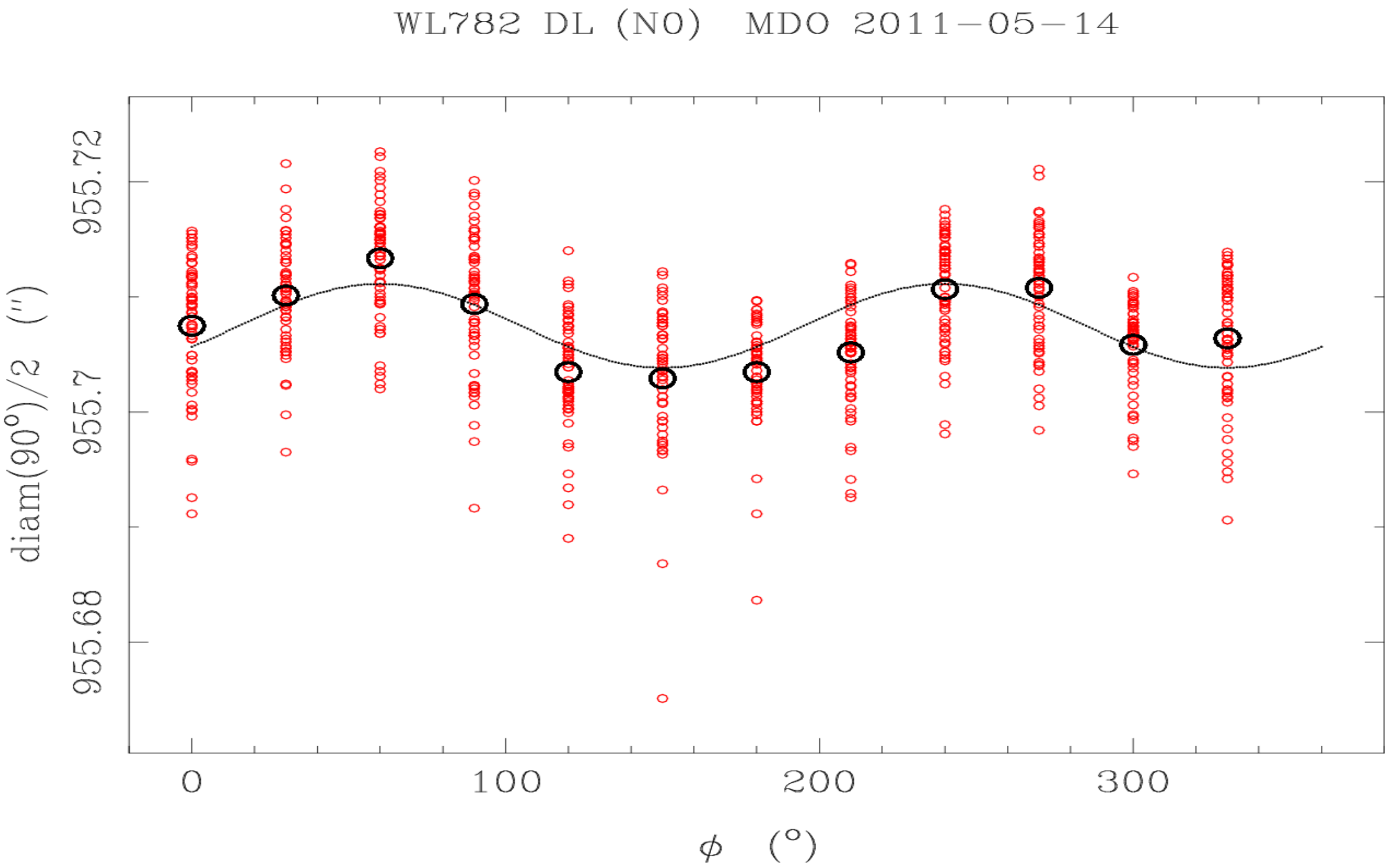
SOLAR OBLATENESS

Modeling of the solar convective zone requires to take into account:

- Magnectic field
- Rotation
-Turbuence

and their interaction

Measurements of solar oblatness provides a means to validate solar models


WL782 DL (N0) MDO 2011−05−14
955.72
955.7
955.68
diam(90°)/2 (″)
0
100
200
300
φ (°)

THE YALE MODEL OF THE SOLAR INTERIOR

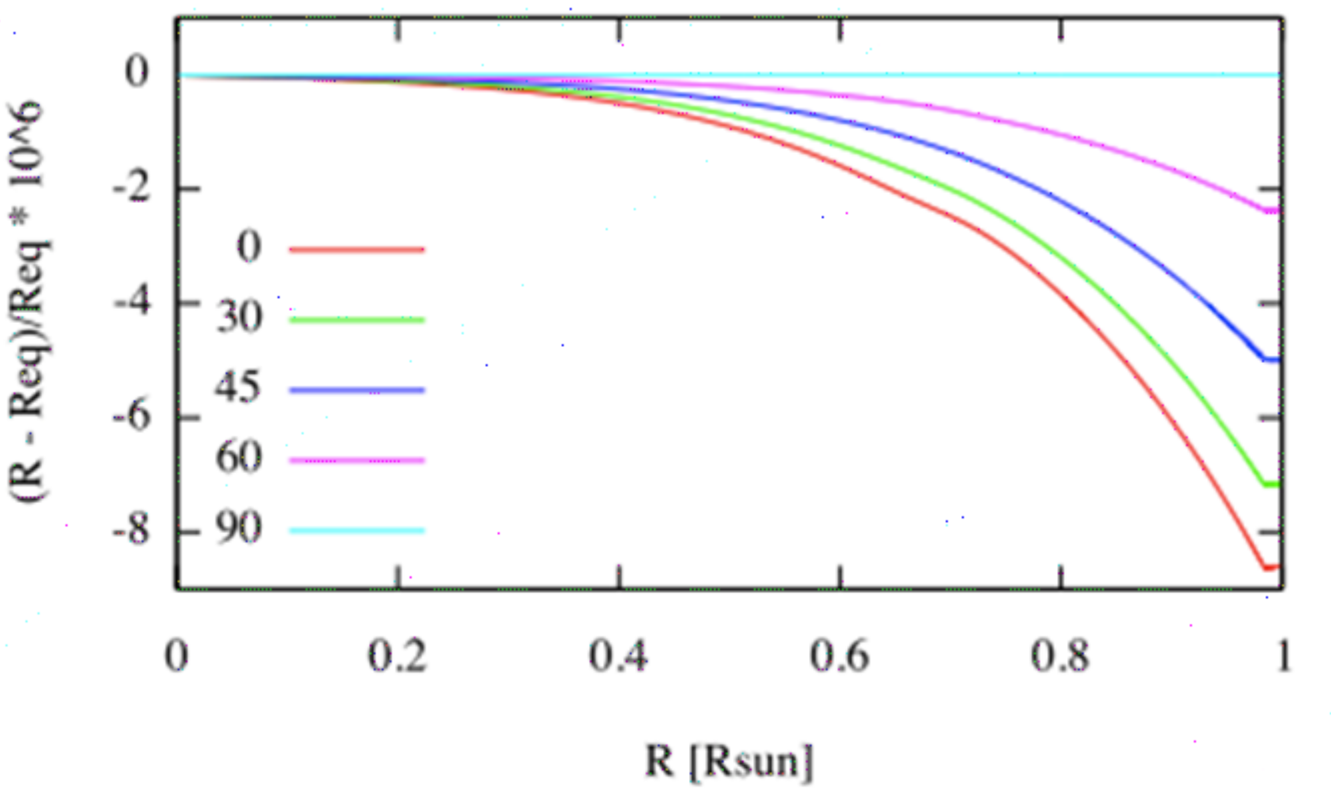
1. TWO-DIMENSIONAL STRUCTURE AND EVOLUTION
2. CONVECTION ZONE
3. INCLUDES MAGNETIC FIELDS, DIFFUSION, ROTATION, AND TURBULENCE

PROPERTIES:

- It is able to simulate the 11-year solar cycle
- It is able to represent p-mode properties as the frequency shift as a function of solar activity.

Modeled solar center to limb variation (CLV) as a function of co-latitude

- A prediction for a certain solar level. It allows to investigate the solar activity influence by changing the amplitude of the magnetic field in the model.



For example for $\Delta R/R = 8\ 10^{-6}$, the model value for oblateness is 7.6 mas.

➔Measured oblateness is compatible with model prediction.

Studies to be made:

- Oblateness at other wavelengths
- Oblateness dependence with solar activity

However, is it a true physical dependence with solar activity or an artefact generated by the technique of measurement (polar areas have no active region, but equatorial regions have)?

Work to do: improve the RMS by appropriate thermal model corrections.

LONG TERM VARIATION OF THE SOLAR RADIUS

It is the major difficulty encountered by SODISM. Its origin is not presently known as no systematic analysis has been performed up to now.
Only the entrance window has been considered. Role of a possible contamination?

Auxiliairy corner images at 535 nm are providing important contribution.
Study in progress.
N1 data taking into account all foreseen corrections (DK, scattered light, FF, internal scale, optical distorsion, psf) is mandatory.

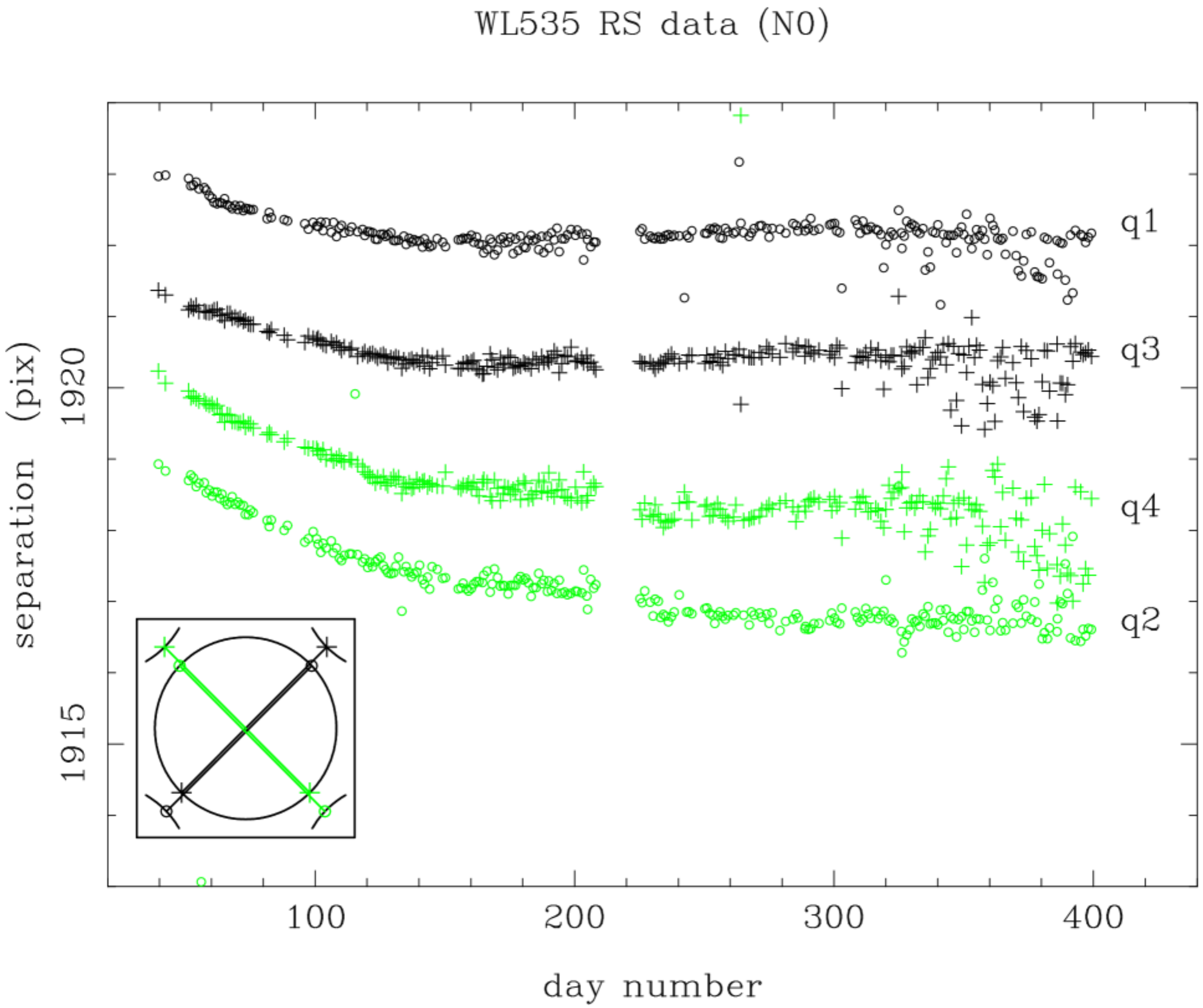
In case, the correction are not precise enough, which data may be used?

BOS HMI-SDO, SDS

BOS measures the solar diameter (white light) in case of solar eclipses by the moon.
Accuracy is presently estimated to 95 mas. It can be improved by taking into account CLV, precise satellite position and lunar limb shape.

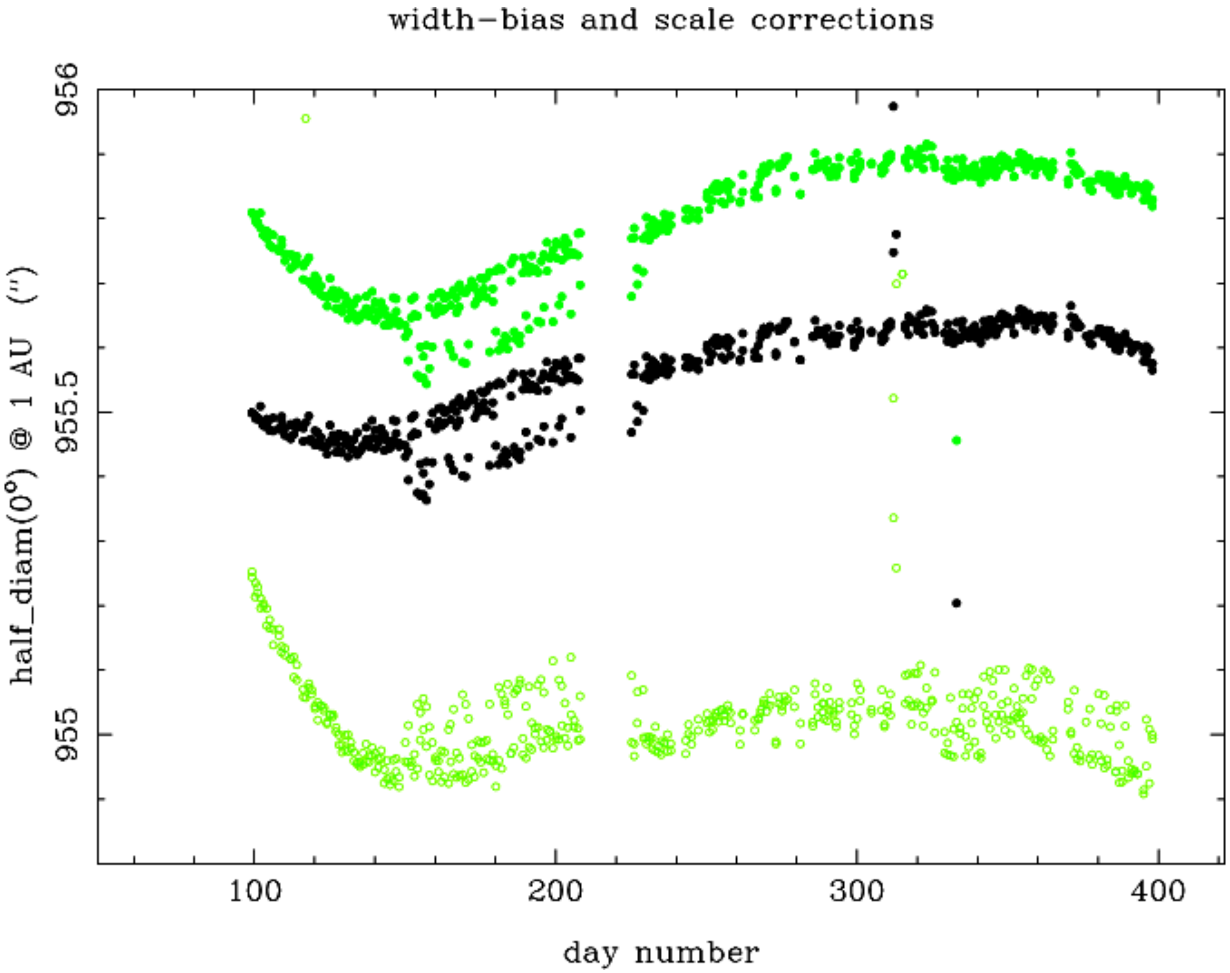
Some ground measurements are also carried out. Data processing in progress.

SODISM Corner Images: Pixel-Scale Variation



NOTE: As N1 data are not available, **N_0** raw data are used (no DK, FF, Scattered light, optical distorsion, and no internal scale corrections). The corner images are noisy (pupils ratio) and the noise level is increasing with time (the CCD detector has an increasing number of defects Increasing with time) .

SODISM Corner Images: Pixel-Scale Correction



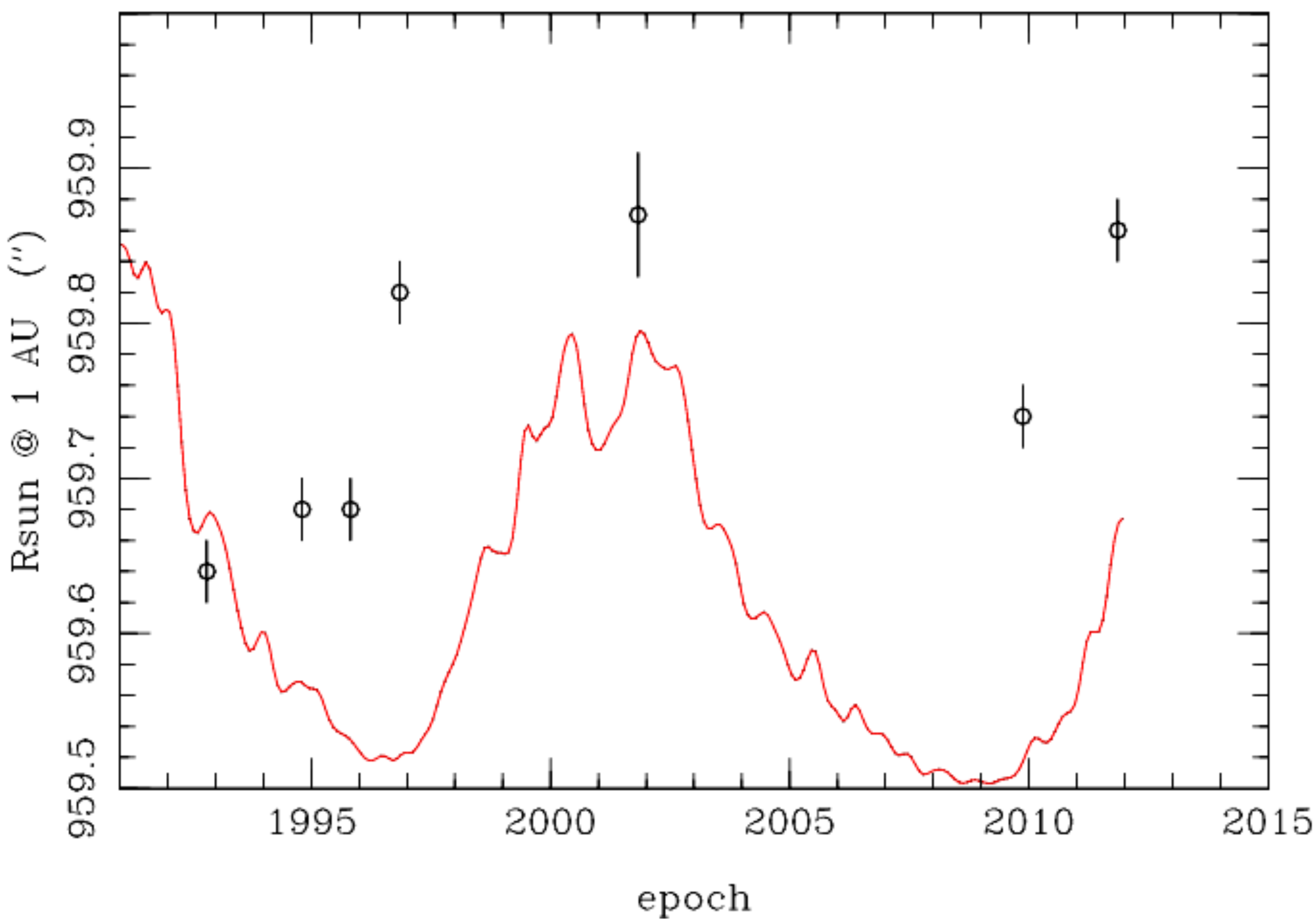
← (width-bias corrected)

← (width-bias & pixel-scale corrected)

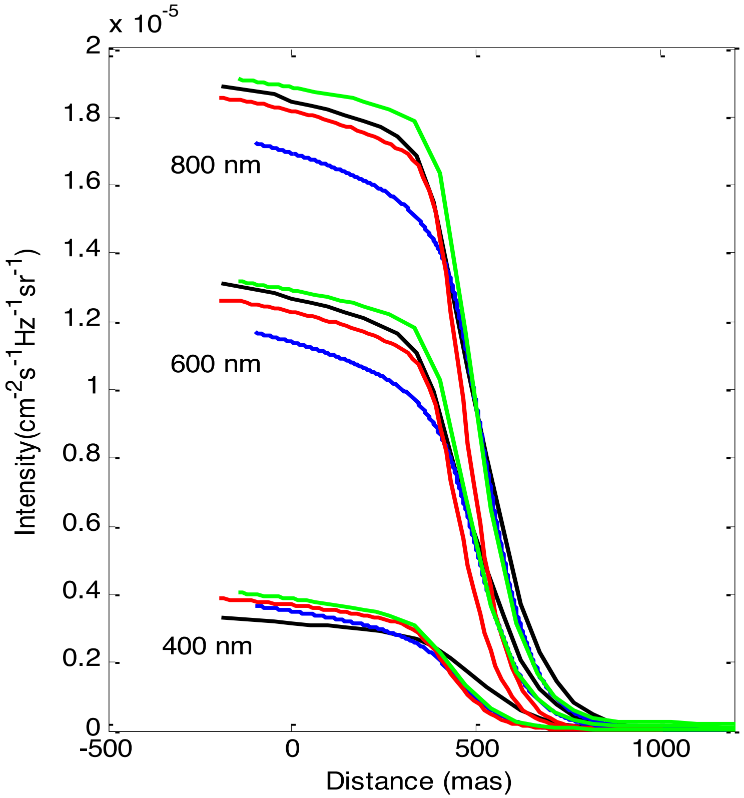
← equatorial Rsun (no corrections)

The peak to peak drift is reduced by a factor two.

SDS: Solar Radius Results



CENTER TO LIMB VARIATION and LIMB SHAPE



Important information for solar atmosphere models validation.

Comparison of Vernazza, FCH, SH, and COSI's models

SODISM :

The limb shape determination requires precise corrections. Today, it is not demonstrated they can be achieved at the necessary level of precision.

The CLV study requires less precision, however, the photometric variation being much smaller. the noise contribution has to be taken into account. This is achievable.

PREMOS : measures the limb shape at the eclipses events.

DIFFERENTIAL ROTATION

The objective is the determination of the solar velocity rotation as a function of latitude and solar activity observed at different wavelengths (i. e. different depth).

The differential rotation depends upon the solar activity cycle. Cycle 24 is abnormal, looking like as cycles 5 and 14.

This study has not been carried out as the team was working on the diameter drift.

But, this subject remains important for solar modeling validation.

Image Pleine RS393 du 2012-03-08 11:53

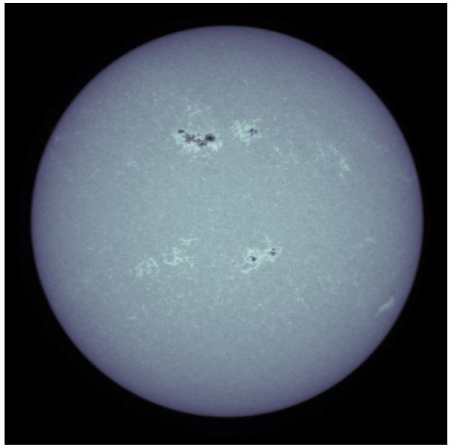


Image Pleine RS393 du 2012-03-09 06:27

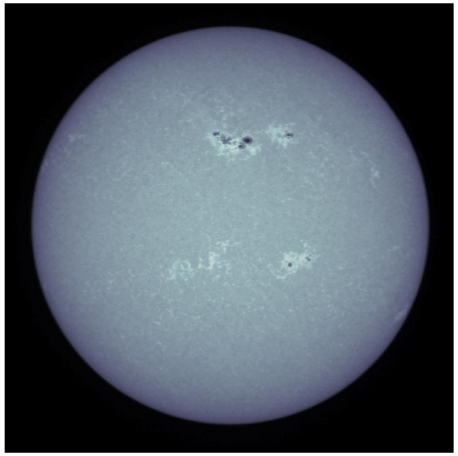


Image Pleine RS393 du 2012-03-10 02:59

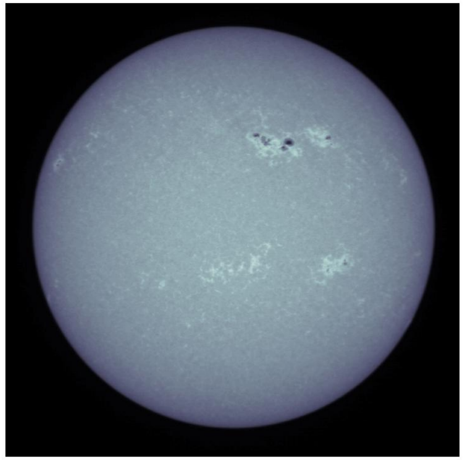


Image Pleine RS535 du 2012-03-08 21:03

Image Pleine RS535 du 2012-03-09 16:51

Image Pleine RS535 du 2012-03-12 17:03

TOTAL SOLAR IRRADIANCE MODELING USING Ca II IMAGES

Importance: solar physics, atmosphere and climate physics

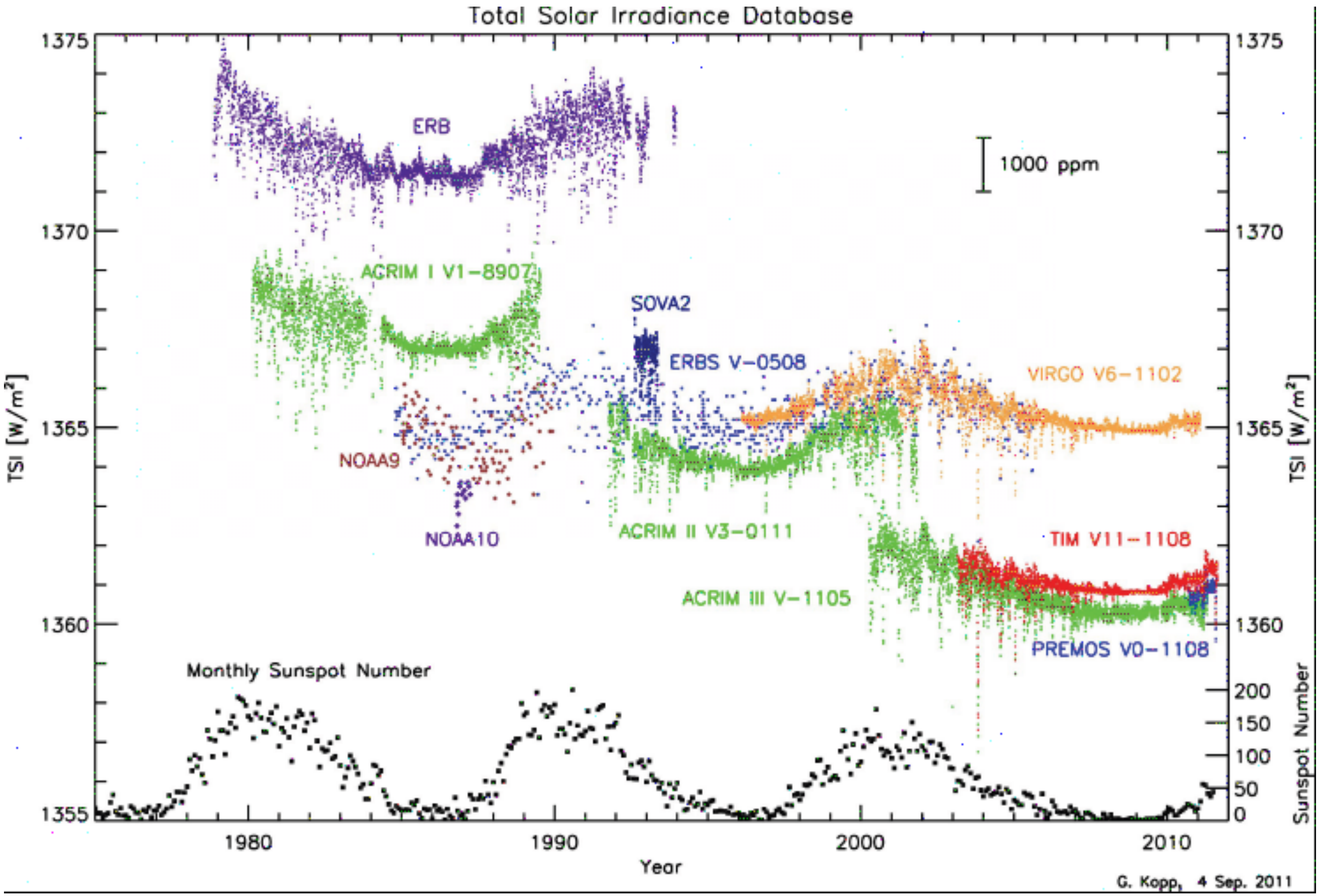
Ca II images from ground have been used to model the TSI as the facula and sunspots have well defined signatures on the image. This work has been made at the scale of day or half day.

Variability is acknowleged to exist at smaller scales.

Today, SODISM resolution allows to work at 50 minutes or less if necessary.

Furthermore, the relationship with PREMOS sunphotometers data has to be explored.

RADIOMETRY AND SPECTRAL PHOTOMETRY



SORCE (TIM) / SoHO : 4.5 W/m^2

RADIOMETRIC MEASUREMENTS SITUATION

Missions	End of mission
TIM/SORCE	2012
VIRGO/ SoHO	2012, 2014 ?
TIM/GLORY	Launch failed
Proba 3	2015 (waiting for decision)
SOLAR C	>= 2018
Kua Fu-A	2017 ?
PICARD	> 2012….

RADIOMETRY:

SOVAP and PREMOS radiometers appear essential to ensure the continuity of the radiometric measurements series initiated in 1978.

Both contribute to study the discrepancy SoHO/SORCE pending *since 2003*.

SPECTROMETRY :

PREMOS will contribute to the variability discrepancy between SIM/SORCE versus SUSIM data, modeling (Lean, Unruh, Mg II) .

VENUS TRANSIT

This phenomenon is mainly relevant of planetogy.

A study of the Venus atmosphere effect on the diameter measurement is on going.

The four instruments will contribute.

SODISM measurements will bring information about its psf, and will provide a sun diameter measurement, however with an accurracy limited by the Venus atmosphere. An accuracy of about 200 mas is expected.

SOLAR MODELING

The PICARD team has also the capability of solar modeling for interpret the measurements.

- Solar atmosphere Model (photosphere and chromosphere)
COSI (PMOD-WRC) is able to predict the solar spectrum and the limb shape.

- Convective zone models and its variability:
    * Montreal University and St Mary University,
    * Yale Unniversity
    * DPNIA (CEA)-LATMOS.

- For Sun/climate connection, two reconstructions have been developed for the PICARD mission by UdM and LATMOS.

STRATEGY (1/2)

1) Measurement corrections

- Dark current
- Scattered light model: essential to calculate the instrument FF
- Flatfield
- Interpolation at the daily scale of the FF data
- Use the corner images
- Optical distorsion and its interpolation at the daily scale
- Use the stellar scale

- Development of a thermal model to correct the perturbations generated by the changing environment (orbital effect, albedo, …)

STRATEGY (2/2)

2) Provide appropriate corrections (e.g. N1 data level) as a function of the scientific objectives.

Scientific objectives	DK	Scattered light	FF	Optical distortion	Internal scale	Stellar scale
Oblateness	X	X	X	X		
Long term solar radius variation	X	X	X	X	X	X
Differential rotation	X		X			
Influence régions actives	X	X	X	X		
Ca II images	X	X	X			
CLV	X	X	X	X		
Venus transit	X	X	X	X		

3) Provide accuracy of the N1 products. Any scientific objective requires a given accuracy.

4) On the short term (orbital frequency, its harmonics, and temporal perturbations generated by the changing albedo (clouds, …), SODISM (and likely other instruments TBC) experiences significant thermal perturbations to such extent that the thermal equilibrium is never reached. Attitude change would help.

CONCLUSIONS

1) Cycle 24 presents unusual characteristiics

- Slow rising,
- Estimated amplitude about 60% of the cycle 23 apmplitude
- Sunspots number
- variations rapides et importantes de son nombre de taches.

⇒ This cycle has to be observed.

2) Scientifiques objectifs and N1 data

N1 data production has the highest priority.

Each scientific aim requires data at a certain level of precision. N1 data precision has to be quoted

3) Absolute radiometric measurements are essential to the TSI series iniated in 1978.

4) SODISM anomaly.
A systematic study should be made including all components from the entrance window to the detector. The BOS instrument provides useful information to study the instrument thermal behaviour. Solar measurements after stellar pointing and eclipses periods provide useful circumstances to validate the instrument thermal model.